

ENERGY EFFICIENCY/RENEWABLE ENERGY IMPACT IN THE TEXAS EMISSIONS REDUCTION PLAN (TERP)

PRELIMINARY REPORT: INTEGRATED NOX EMISSIONS SAVINGS FROM EE/RE PROGRAMS STATEWIDE

**Annual Report to the
Texas Commission on Environmental Quality
January 2017 – December 2017**



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ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION



**TEXAS A&M ENGINEERING
EXPERIMENT STATION**

ENERGY SYSTEMS LABORATORY

December 10, 2018

Mr. Robert Gifford
Air Quality Planning Section
Air Quality Division, Office of Air
Texas Commission on Environmental Quality Austin, TX 78711-3087

Dear Mr. Gifford:

The Energy Systems Laboratory (ESL) at the Texas A&M Engineering Experiment Station of the Texas A&M University System is pleased to provide this preliminary report, "Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP): Integrated NOx Emissions Savings from EE/RE Programs Statewide," as required under Texas Health and Safety Code Ann. § 388.003 (e) (Senate Bill 5, 77R as amended 78 R & 78S).

The ESL is required to annually report the energy savings from statewide adoption of the Texas Building Energy Performance Standards in Senate Bill 5 (SB 5), as amended, and the relative impact of proposed local energy code amendments in the Texas non-attainment and near-non-attainment counties as part of the Texas Emissions Reduction Plan (TERP).

Please contact me at (979) 845-9213 should you or any of the TCEQ staff have any questions concerning this report or any of the work presently being done to quantify emissions reductions from energy efficiency and renewable energy measures as a result of the TERP implementation.

Sincerely,

A handwritten signature in black ink that reads "David E. Claridge". The signature is written in a cursive, flowing style.

David E. Claridge, Ph.D., P.E., FASHRAE
Director

Disclaimer

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PRELIMINARY REPORT: INTEGRATED NOX EMISSIONS SAVINGS FROM EE/RE STATEWIDE

Energy Efficiency/Renewable Energy Impact In The Texas Emissions Reduction Plan

Executive Summary

The Energy Systems Laboratory (Laboratory), at the Texas A&M Engineering Experiment Station of the Texas A&M University System, in fulfillment of its responsibilities under Texas Health and Safety Code Ann. § 388.003 (e), submits this annual report, Energy Efficiency/Renewable Energy (EE/RE) Impact in the Texas Emissions Reduction Plan (Preliminary Report) to the Texas Commission on Environmental Quality.

This preliminary report shows the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2022 for both the annual and Ozone Season Period (OSP)¹ NOx reductions. The year 2008 was used for the baseline year to estimate the emissions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2016 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose.

In 2017, the integrated total electricity savings from all programs are:

- Annual electricity savings is 67,896,655 MWh/year (33,150 tons-NOx/year) and
- OSP electricity savings is 147,731 MWh/day, which would be a 6,155 MW average hourly load reduction during the OSP period (73.93 tons-NOx/day).

By 2022, the integrated total electricity savings from all programs are:

- Annual electricity savings will be 105,240,482 MWh/year (51,321 tons-NOx/year) and
- OSP electricity savings will be 229,873 MWh/day, which would be a 9,578 MW average hourly load reduction during the OSP period (114.99 tons-NOx/day).

A summary of the savings for 2017 and 2022 is presented in the table below. (Base year 2008)

	2017	2022
Annual Electricity Savings (MWh/year)	67,896,655	105,240,482
Annual Emissions Reductions (tons NOx/year)	33,150	51,321
OSP Electricity Savings (MWh/day)	147,731	229,873
OSP Emissions Reductions (tons NOx/day)	73.93	114.99

¹ An ozone season period (OSP) represents the daily average emissions during the period that runs from mid-July to mid-September.

Legislative Background

In 2001, the Texas Emissions Reduction Plan (TERP), established by the 77th Texas Legislature with the enactment of Senate Bill 5 (SB 5), identified that Energy Efficiency and Renewable Energy (EE/RE) measures make an important contribution to a comprehensive approach for meeting the minimum federal ambient air quality standards. In 2003 through 2007, the 78th, 79th and 80th Legislatures enhanced the use of EE/RE programs for meeting the TERP. The 78th Legislature enhanced the use of EE/RE programs for meeting TERP goals by requiring the Texas Commission on Environmental Quality (TCEQ) to promote EE/RE as a means to improve air quality standards and to develop a methodology for computing emissions reduction for use in the State Implementation Plan (SIP) from EE/RE programs.

The 79th Legislature expanded the scope of the SIP-eligible credits by adding savings from the State Renewable Portfolio Standards from the generation of electricity from renewable sources; specifically requiring the TCEQ to develop methods to quantify emissions reductions from renewable energy; and required the Laboratory to develop at least 3 alternative methods for achieving a 15 percent greater potential energy savings in residential, commercial and industrial construction.

In the 80th Legislature several new energy efficiency initiatives were introduced, including: requiring the Laboratory to provide written recommendations to the State Energy Conservation Office (SECO) about whether or not the energy efficiency provisions of latest published edition of the International Residential Code (IRC), or the International Energy Conservation Code (IECC), are equivalent to or better than the energy efficiency and air quality achievable under the editions adopted under the 2001 IRC/IECC; requiring the Laboratory to develop a standardized report format to be used by providers of home energy ratings; and encouraging the Laboratory to cooperate with an industry organization or trade association to develop guidelines for home energy ratings, including training.

The 81st Legislature (2009) extended the TERP to 2019 and required the TCEQ to contract with Laboratory to compute emissions reduction from wind and other renewable energy resources for the SIP.

The 82nd Legislature (2011), the Laboratory's responsibilities under TERP increased as new legislatively allocated energy efficiency initiatives were introduced.

The 83rd, 84th, and 85th Legislatures (2013, 2015, and 2017 respectively) the Laboratory's responsibilities under TERP were kept the same as previous years.

Calculation of Integrated NO_x Emissions Reductions from Multiple State Agencies Participating in the Texas Emissions Reduction Plan (TERP)

In January 2005, the Laboratory was asked by the Texas Commission on Environmental Quality (TCEQ) to develop a method by which the NO_x emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 could be reported in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2022 for both the annual and Ozone Season Period (OSP) NO_x reductions. In 2017, the NO_x emissions reductions from all these programs were calculated using estimated emissions factors for 2016 from the US

Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose. The different programs included in this 2017 integrated analysis are:

- ESL Single-family, Multi-family, and Commercial new constructions
- PUC Senate Bill 7 Program
- SECO Senate Bill 5 Program
- Electricity generated by renewables in Texas (ERCOT)²
- SEER 13 upgrades to Single-family and Multi-family residences

The Laboratory's single-family and multi-family programs include the energy savings attained by constructing new residences in Texas. The baseline to estimate energy savings uses the published data on residential construction characteristics by the 2008 National Association of Home Builders (NAHB 2008) based on the 2006 IECC building code (2006 ICC). Annual electricity savings (MWh) are obtained from the Laboratory's Annual Reports to the TCEQ (Haberl et al., 2002 - 2017).

The Laboratory's commercial program includes the energy savings attained by constructing new commercial buildings in Texas, including office, apartment, healthcare, education, retail, food and lodging as defined by Dodge building type (Dodge 2011). Energy savings were estimated from code compliant buildings (ASHRAE Standard 90.1-2013) against pre-code buildings (ASHRAE Standard 90.1-2007) using the energy use intensity (EUI) in the USDOE report and constructed square footage in Dodge data (Dodge 2017).

The Public Utility Commission of Texas (PUC) Senate Bill 7 program includes the energy efficiency programs implemented by electric utilities under the Public Utility Regulatory Act §39.905. The PUC regulated energy efficiency program was adopted pursuant to 1999 legislation (SB 7) and subsequent legislation in 2001 (SB 5), 2007 (HB 3693), and 2011 (SB 1125). The energy efficiency measures include: high efficiency HVAC equipment, variable speed drives, increased insulation levels, infiltration reduction, duct sealing, Energy Star Homes, etc. Annual electricity savings claimed by the utilities were reported for the different programs completed in the years 2001 through 2017.

The Texas State Energy Conservation Office (SECO) funds energy-efficiency programs that are directed towards school districts, government agencies, city and county governments, private industries and residential energy consumers. For the 2017 reporting year SECO submitted annual energy savings values for projects funded by SECO and by Energy Service projects.

The Electric Reliability Council of Texas (ERCOT) electricity production from currently installed green power generation in Texas is reported. Actual measured electricity productions for 2001 through 2017 were included. For projections to 2022, the annual growth factor was estimated using the last six years installed power capacity.

Finally, NO_x emissions reductions from *the installation of SEER 13 air conditioners in existing residences* are also reported.

² ERCOT is the Electric Reliability Council of Texas.

Description of the Analysis Method

Annual and Ozone Season Period (OSP) NOx emissions reductions were calculated for 2017 and integrated from 2009 to 2022 using several factors to discount the potential savings. These factors include an annual degradation factor, a transmission and distribution factor, a discount factor, and growth factors as shown in Table 1 and are described as follows:

Annual degradation factor: This factor was used to account for an assumed decrease in the performance of the measures installed as the equipment wears down and degrades. With the exception of electricity generated from renewables, an annual degradation factor of 2% was used for ESL Single-family, Multi-family, and Commercial programs and an annual degradation factor of 5% was used for all other programs³. The value of the 5% degradation factor was taken from a study by Kats et al. (1996).

Transmission and distribution loss: This factor adjusts the reported savings to account for the loss in energy resulting from the transmission and distribution of the power from the electricity producers to the electricity consumers. For this calculation, the energy savings reported at the consumer level are increased by 7% to give credit for the actual power produced that is lost in the transmission and distribution system on its way to the customer. In the case of electricity generated by renewables, the T&D losses were assumed to cancel out since renewable energy is displacing power produced by conventional power plants; therefore, there is no net increase or decrease in T&D losses.

Initial discount factor: This factor was used to discount the reported savings for any inaccuracies in the assumptions and methods employed in the calculation procedures. For the Laboratory's Single, Multi-family and Commercial program, the discount factor was assumed to be 20%. For PUC's Senate Bill 7 program, the discount factor was taken as 10%. For the savings in the SECO program, the discount factor was 60%. For the electricity from renewables, the discount factor was taken as 5%. In addition, the discount factor for SEER 13 single-family and SEER 13 multi-family program was 20%.

Growth factor: The growth factors shown in Table 1 were used to account for several different factors. Growth factors for single-family (4.1%), multi-family residential (6.1%), and commercial (5.3%) construction are projections based on the average growth rate for these housing types from recent U.S. Census data for Texas. Growth factor for renewable energy (8.5%) is a linear projection based on the installed renewable power generation capacity for 2009 through 2017 from the Public Utility Commission of Texas. No growth was assumed for PUC programs, SECO, and SEER 13 entries.

Figure 1 shows the overall information flow that was used to calculate the NOx emissions savings from the annual and OSP electricity savings (MWh) from all programs. For the Laboratory's single-family and multi-family code-implementation programs, the annual and OSP were calculated from DOE-2 hourly simulation models⁴. The base case is taken as the average characteristics of single- and multi-family residences for Texas published by the National Association of Home Builders for 2008 (NAHB 2008) and 2006 IECC. The annual electricity

³ A degradation of 5% per year would accumulate as a 5%, 10%, 15%...etc, degradation in performance. Although the assumption of this high level of degradation may not actually occur, it was chosen as a conservative estimate. For renewable energy, a degradation factor of 0% was used. The choice of a 0% degradation factor for renewables is based on two years of analysis of measured wind data from all Texas wind farms that shows no degradation, on average, for a two year period after the wind farms became operational.

⁴ These values are based on a performance analysis as defined by Chapter 4 of the 2006, 2009 and 2015 IECC, plus the corresponding NAHB and HIRL data.

savings from PUC's energy efficiency programs were calculated using PUC approved demand savings calculations or tables or industry accepted measurement and verification methods (PUC 2018). The OSP consumption is the average daily consumption for the period between July 15 and September 15.

The SECO electricity savings were submitted as annual savings by project⁵. A description of the measures completed for the project was also submitted for information purposes. The electricity production from renewables in Texas was from the actual on-site metered data measured at 15-minute intervals except non-utility scale solar photovoltaic (PV) projects.

Integration of the savings from the different programs into a uniform format allowed for creditable NOx emissions to be evaluated using different criteria as shown in Table 1. These include evaluation across programs, evaluation across individual counties by program, evaluation by SIP area, evaluation for all ERCOT counties except Houston/Galveston, and evaluation within a 200 km radius of Dallas/Ft. Worth.

Calculation Procedure

The electricity savings in this report was estimated based on the baseline year of 2008. In addition, the emissions estimation throughout this report was updated to the 2016 eGrid database, which is applied to the four different Competitive Load (CL) zones: Houston, North, West, and South. For all the programs, except renewable projects, the corresponding OSP emissions reductions were calculated using an annual daily average. The OSP emissions reductions from the electricity generated by renewables except non-utility scale solar PV and biomass projects were estimated by actual measured data.

ESL Single-family and Multi-family. The calculation of the annual electricity savings reported for the years 2002 through 2017 included the savings from code-compliant new housing in all 42 non-attainment and affected counties as reported in the Laboratory's annual report submitted by the Laboratory to the Texas Commission of Environmental Quality (TCEQ). From 2009 to 2017, based on year 2008, the annual electricity savings were calculated for new residential construction in all the counties in ERCOT region, which includes the 42 non-attainment and affected counties. These savings were then tabulated by county and program. Using the calculated values through 2017, savings were then projected to 2022 by incorporating the different adjustment factors mentioned above.

In these calculations, it was assumed that the same amount of electricity savings from the code-complaint construction would be achieved for each year after 2017 through 2022⁶. The projected energy savings through 2022, according to county, were then divided into the CL zones in the 2016 eGRID. To determine which CL zone was to be used, or in counties with multiple CL zone, the allocation to each CL zone by county was obtained from CL zone's listing published in the Laboratory's 2010 annual report⁷.

⁵ The reporting requirements to the SECO did not require energy savings by project type, although for selected sites, energy savings by project type was available.

⁶ This would include the appropriate discount and degradation factors for each year.

⁷ Haberl et al., 2010, pp. 265.

For the 2017 annual NOx emissions calculations, the US EPA's 2016 eGRID were used. An example of the eGRID spreadsheet⁸ is given in the Table 2. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors contained in eGRID. Similar calculations were performed for each year for which the analysis was required.

ESL-Commercial Buildings. The annual electricity savings for 2004 through 2017 for commercial buildings were obtained from the annual reports for 2004 through 2017 submitted by the Laboratory to TCEQ⁹. From 2009 to 2017, based on year 2008, the annual electricity savings were also calculated for new commercial construction by county. Using the calculated savings through 2017, savings were then projected to 2022 by incorporating the different adjustment factors mentioned above¹⁰. In the projected annual electricity savings, it was assumed that the same 2017 amount of electricity savings would be achieved for each year through 2022. Similarly to the single family calculations, the projected energy saving numbers through 2022, by county, were allocated into the appropriate CL zones.

PUC-Senate Bill 7. For the PUC Senate Bill 7 program savings, the annual electricity savings for 2001 through 2017 were obtained from the Public Utility Commission of Texas. Using these values savings were projected through 2022 by incorporating the different adjustment factors mentioned above. Similar savings were assumed for each year after 2017 until 2022. The 2016 annual eGRID was also used to calculate the NOx emissions savings for the PUC-Senate Bill 7 program. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each county using the emissions factors contained in the US EPA's eGRID spreadsheet. The integrated NOx emissions reductions for each county were then calculated.

SECO Savings. The annual electricity consumption reported by political subdivisions for 2017 were obtained from the State Energy Conservation Office (SECO). Using the reported consumption, the annual and OSP electricity savings resulted from energy conservation projects were then calculated. To achieve this, the annual energy use intensity (EUI) for each county was estimated and the county's energy savings for each year against the baseline year of 2008 were then calculated¹¹. In addition, the savings through 2022 were projected using the different adjustment factors mentioned above. In a similar fashion to the previous programs, it was assumed that the same amount of electricity savings will be achieved for each year through 2022. The 2016 annual eGRID was also used to calculate the NOx emissions savings for the SECO program.

Electricity Generated by Renewables. The measured and estimated electricity production from renewables in Texas for 2008 through 2017 was obtained from reports of *Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP) - Technical Report (2009-2010)* for 2008 through 2009 data and *Statewide Air Emissions Calculations from Wind and Other Renewables (2011-2018)* for 2010 through 2017 data. Using the reported numbers for 2017, savings through 2022 were projected incorporating the different adjustment

⁸ To use this spreadsheet electricity savings for each eGRID zone is entered in the bottom row of the spreadsheet (MWh). The spreadsheet then allocates the MWh of electricity savings according to the counties (blue columns) where the CL zone owned and operated a power plant. Totals for all CL zones are then listed on the far right columns (white columns). Similar spreadsheets for the 2016 eGRID exist for SOx and CO2.

⁹ These savings include new construction in office, education, retail, food, lodging and warehouse construction as defined by Dodge building type (Dodge 2011), using energy savings from the US DOE's report (USDOE 2011), and data from CBECS (1995 - 2012) and Dodge (2017).

¹⁰ This also includes the appropriate discount and degradation factors for each year.

¹¹ In the 2017 report, EUI values were used to calculate the electricity savings. This calculation method was also applied to savings estimation for the previous years from 2009 to 2016.

factors mentioned above. The 2010 eGRID was used for the period of 2008 through 2016 and 2016 eGRID was then used for the period of 2017 through 2022 to calculate the NOx emissions reductions for the electricity generated by renewables in Texas. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties.

SEER 13 Single-Family and Multi-Family. In January of 2006, Federal regulations mandated that the minimum efficiency for residential air conditioners be increased to SEER 13 from the previous SEER 10. Although the electricity savings from new construction reflected this change in values, the annual and OSP electricity savings from the replacement of the air conditioning units by air conditioners with an efficiency of SEER 13 in existing residences needed to be calculated. In this analysis, it was assumed that an equal number of existing houses had their air conditioners replaced, as reported for 2006, by the air conditioner manufacturers. This replacement rate continued until all the existing air conditioner stock was replaced with SEER 13 air conditioners.¹²

In the 2017 report to the TCEQ, the annual and OSP electricity savings for all the counties in ERCOT region as well as the 42 non-attainment and affected counties were calculated. Using the numbers for 2008, the savings after 2008 until 2022 were projected by incorporating the appropriate adjustment factors¹³. The total electricity savings for each CL zone were used to calculate the NOx emissions reductions for each of the different counties using the emissions factors contained in the 2016 eGRID. Integrated NOx emissions reductions for each county by ozone non-attainment and affected counties were also calculated.

Results

The total integrated annual and OSP electricity savings for all the different programs in the integrated format were calculated for 2009 through 2022 as shown in Table 3, using the adjustment factors shown in Table 1. Annual and OSP NOx emissions reductions from the electricity savings (presented in Table 3) for all the programs in the integrated format were shown in Table 4.

In 2017, the total integrated annual savings from all programs are 56,457,081 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 4,034,136 MWh/year (7.1% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program are 3,844,949 MWh/year (6.8%),
- Savings from SECO's Senate Bill 5 program are 1,275,938 MWh/year (2.3%),
- Electricity savings from renewable power generation are 47,055,032 MWh/year (83.3%), and
- Savings from residential air conditioner retrofits¹⁴ are 247,025 MWh/year (0.4%).

¹² In 2011, the U.S.DOE revised the energy conservation standards for residential HVAC systems. Beginning in January 2015, split-system central air conditioners installed in Texas must be at least SEER 14. NOx emissions reductions from SEER 14 replacement air conditioners will be included in future TERP reports as statewide sales data can be evaluated.

¹³ Additional details about this calculation are contained in the Laboratory's 2008 Annual Report to the TCEQ, available at the Senate Bill 5 web site "<http://esl.tamu.edu/>".

¹⁴ This assumes air conditioners in existing homes are replaced with the more efficient SEER 13 units, versus an average of SEER 11, which is slightly more efficient than the previous minimum standard of SEER 10.

In 2017, the total integrated OSP savings from all programs are 123,280 MWh/day, which would be a 5,137 MW average hourly load reduction during the OSP period. The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction are 11,052 MWh/day (9.0%),
- Savings from the PUC's Senate Bill 7 programs are 10,534 MWh/day (8.5%),
- Savings from SECO's Senate Bill 5 program are 3,496 MWh/day (2.8%),
- Electricity savings from renewable power generation are 96,446 MWh/day (78.2%), and
- Savings from residential air conditioner retrofits are 1,752 MWh/day (1.4%).

By 2022, the total integrated annual savings from all programs will be 87,687,961 MWh/year. The integrated annual electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 9,380,917 MWh/year (10.7% of the total electricity savings),
- Savings from the PUC's Senate Bill 7 program will be 5,332,467 MWh/year (6.1%),
- Savings from SECO's Senate Bill 5 program will be 2,028,819 MWh/year (2.3%),
- Electricity savings from renewable power generation will be 70,754,614 MWh/year (80.7%), and
- Savings from residential air conditioner retrofits will be 191,143 MWh/year (0.2%).

By 2022, the total integrated OSP savings from all programs will be 192,246 MWh/day, which would be a 8,010 MW average hourly load reduction during the OSP period. The integrated OSP electricity savings from all the different programs are:

- Savings from code-compliant residential and commercial construction will be 25,701 MWh/day (13.4%),
- Savings from the PUC's Senate Bill 7 programs will be 14,609 MWh/day (7.6%),
- Savings from SECO's Senate Bill 5 program will be 5,558 MWh/day (2.9%),
- Electricity savings from renewable power generation will be 145,021 MWh/day (75.4%), and
- Savings from residential air conditioner retrofits will be 1,356 MWh/day (0.7%).

In 2017 (Table 4), the total integrated annual NO_x emissions reductions from all programs are 27,065 tons-NO_x/year. The integrated annual NO_x emissions reductions from all the different programs are:

- NO_x emissions reductions from code-compliant residential and commercial construction are 1,213 tons-NO_x/year (4.5% of the total NO_x savings),
- NO_x emissions reductions from the PUC's Senate Bill 7 programs are 1,326 tons-NO_x/year (4.9%),
- NO_x emissions reductions from SECO's Senate Bill 5 program are 400 tons-NO_x/year (1.5%),
- NO_x emissions reductions from renewable power generation are 24,054 tons-NO_x/year (88.9%), and
- NO_x emissions reductions from residential air conditioner retrofits are 72 tons-NO_x/year (0.3%).

In 2017, the total integrated OSP NO_x emissions reductions from all programs are 59 tons-NO_x/day. The integrated OSP NO_x emissions reductions from all the different programs are:

- NO_x emissions reductions from code-compliant residential and commercial construction are 3.36 tons-NO_x/day (5.7%),

- NOx emissions reductions from the PUC's Senate Bill 7 programs are 3.75 tons-NOx/day (6.4 %),
- NOx emissions reductions from SECO's Senate Bill 5 program are 1.12 tons-NOx/day (1.9%),
- NOx emissions reductions from renewable power generation are 50.25 tons-NOx/day (85.2%), and
- NOx emissions reductions from residential air conditioner retrofits are 0.52 tons-NOx/day (0.9%).

By 2022, the total integrated annual NOx emissions reductions from all programs will be 41,612 tons-NOx/year. The integrated annual NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 2,891 tons-NOx/year (6.9% of the total NOx savings),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 1,833 tons-NOx/year (4.4%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 665 tons-NOx/year (1.6%),
- NOx emissions reductions from renewable power generation will be 36,169 tons-NOx/year (86.9%), and
- NOx emissions reductions from residential air conditioner retrofits will be 55 tons-NOx/year (0.1%).

By 2022, the total integrated OSP NOx emissions reductions from all programs will be 91 tons-NOx/day. The integrated OSP NOx emissions reductions from all the different programs are:

- NOx emissions reductions from code-compliant residential and commercial construction will be 7.99 tons-NOx/day (8.8%),
- NOx emissions reductions from the PUC's Senate Bill 7 programs will be 5.19 tons-NOx/day (5.7%),
- NOx emissions reductions from SECO's Senate Bill 5 program will be 1.85 tons-NOx/day (2.0%),
- NOx emissions reductions from renewable power generation will be 75.57 tons-NOx/day (83.0%), and
- NOx emissions reductions from residential air conditioner retrofits will be 0.40 tons-NOx/day (0.4%).

Summary

This preliminary report presents the NOx emissions reductions from the energy-efficiency programs from multiple Texas State Agencies working under Senate Bill 5 and Senate Bill 7 in a uniform format to allow the TCEQ to consider the combined savings for Texas' State Implementation Plan (SIP) planning purposes. This required that the analysis should include the integrated savings estimation from all projects projected through 2022 for both the annual and OSP NOx reductions. The NOx emissions reductions from all these programs were calculated using estimated emissions factors for 2016 from the US Environmental Protection Agency (US EPA) eGRID database, which had been specially prepared for this purpose.

In 2017, the integrated total electricity savings from all programs are:

- Annual electricity savings is 56,457,081 MWh/year (27,065 tons-NOx/year) and

- OSP electricity savings is 123,280 MWh/day, which would be a 5,137 MW average hourly load reduction during the OSP period (59 tons-NOx/day).

By 2022, the integrated total electricity savings from all programs are:

- Annual electricity savings will be 87,687,961 MWh/year (41,612 tons-NOx/year) and
- OSP electricity savings will be 192,246 MWh/day, which would be a 8,010 MW average hourly load reduction during the OSP period (91 tons-NOx/day).

The Laboratory has and will continue to provide leading-edge technical assistance to counties and communities working toward obtaining full SIP credit for the energy efficiency and renewable energy projects that are lowering NOx emissions and improving the air quality for all Texans. The Laboratory will continue to provide superior technology to the State of Texas through efforts with the TCEQ and US EPA. The efforts taken by the Laboratory have produced significant success in bringing EE/RE closer to US EPA acceptance in the SIP for Texas.

If any questions arise, please contact us by phone at 979-845-9213.

Table 1: Final Adjustment Factors used for the Calculation of the Annual and OSP NOx Savings for the Different Programs

	ESL-Single Family	ESL-Multifamily	ESL-Commercial	PUC (SB7)	SECO	Renewables-ERCOT	SEER13 Single Family	SEER13 Multi Family
Annual Degradation Factor	2.0%	2.0%	2.0%	5.0%	5.0%	0.0%	5.0%	5.0%
T&D Loss	7.0%	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor	20.0%	20.0%	20.0%	10.0%	60.0%	5.0%	20.0%	20.0%
Growth Factor	4.1%	6.1%	5.3%	0.0%	0.0%	8.5%	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	Yes	Yes

Note: For Renewables-ERCOT, the OSP energy consumption is the average daily consumption of the measured data from mid-July to mid-September.

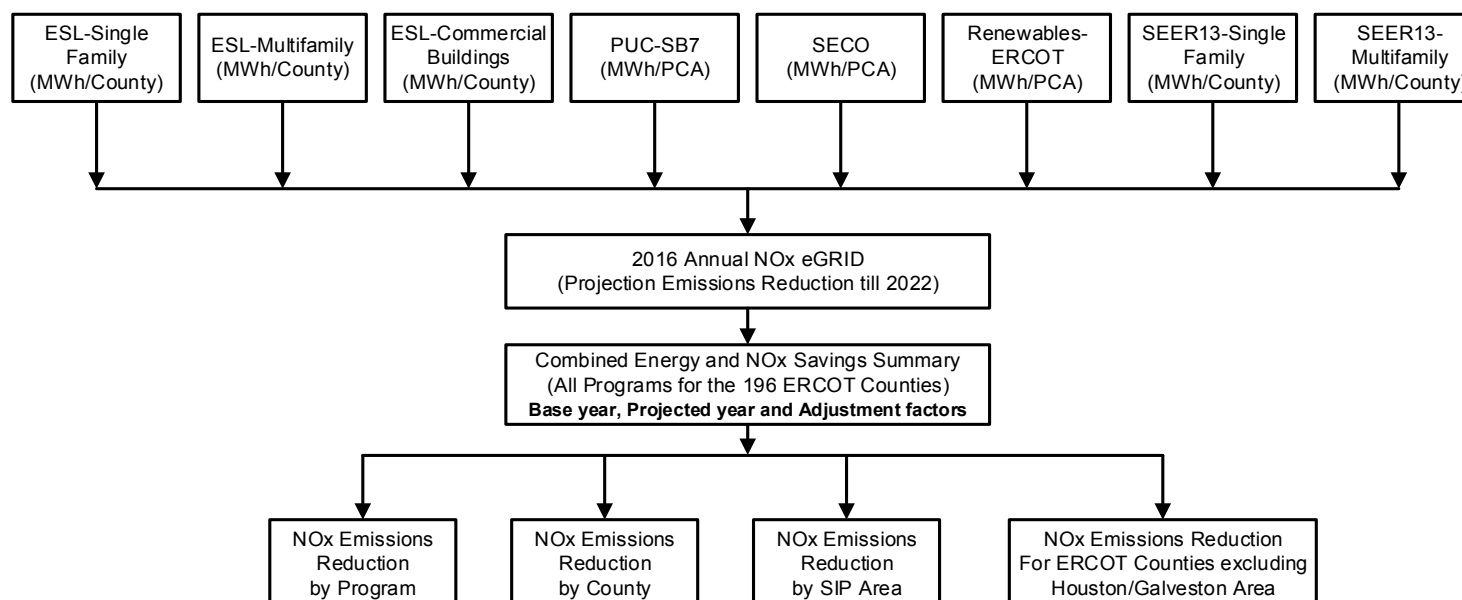


Figure 1: Process Flow Diagram of the NOx Emissions Reduction Calculations

Table 2: Example of NOx Emissions Reduction Calculations using 2016 eGRID

Area	County	CLZones					Total NOx Reductions (lbs)	Total NOx Reductions (Tons)				
		H	N	W	S							
Houston-Galveston Area	Brazoria	0.0568294	172.4766	0.0000072	0.0361	0.0000003	0.0004	0.0005324	0.6473	173.16	0.09	
	Chambers	0.0246685	74.8688	0.0000031	0.0157	0.0000002	0.0002	0.0002311	0.2810	75.17	0.04	
	Fort Bend	0.0916210	278.0689	0.0000116	0.0582	0.0000006	0.0007	0.0008584	1.0436	279.17	0.14	
	Galveston	0.0118565	35.9845	0.0000015	0.0075	0.0000001	0.0001	0.0001111	0.1350	36.13	0.02	
	Harris	0.1083409	328.8136	0.0000137	0.0688	0.0000007	0.0008	0.0010150	1.2340	330.12	0.17	
	Liberty	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Montgomery	0.0093310	28.3196	0.0000012	0.0059	0.0000001	0.0001	0.0000874	0.1063	28.43	0.01	
	Waller	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Hardin	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Jefferson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Beaumont/ Port Arthur Area	Orange	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Collin	0.0000368	0.1117	0.0002257	1.1300	0.0000109	0.0139	0.0000023	0.0028	1.26	0.00	
	Dallas	0.0019990	6.0668	0.0122626	61.3975	0.0005923	0.7561	0.0001251	0.1521	66.37	0.03	
	Denton	0.0012011	3.6454	0.0073682	36.8918	0.0003559	0.4543	0.0000752	0.0914	41.08	0.02	
	Tarrant	0.0007589	2.3033	0.0046556	23.3099	0.0002249	0.2870	0.0000475	0.0577	25.96	0.01	
	Ellis	0.0011262	3.4180	0.0069087	34.5910	0.0003337	0.4280	0.0000705	0.0867	38.52	0.02	
	Johnson	0.0002237	0.6788	0.0013721	6.8701	0.0000663	0.0846	0.0000140	0.0170	7.65	0.00	
	Kaufman	0.0025504	7.7405	0.0156455	78.3355	0.0007557	0.9646	0.0001596	0.1941	87.23	0.04	
	Parler	0.0004992	1.5150	0.0030622	15.3319	0.0001479	0.1888	0.0000312	0.0380	17.07	0.01	
	Rockwall	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Dallas/ Fort Worth Area	Henderson	0.0002092	0.6350	0.0012835	6.4265	0.0000620	0.0791	0.0000131	0.0159	7.16	0.00	
	Hood	0.0017809	5.4049	0.0109248	54.6991	0.0005277	0.6736	0.0001115	0.1355	60.91	0.03	
	Hunt	0.0000552	0.1676	0.0003387	1.6960	0.0000164	0.0209	0.0000035	0.0042	1.89	0.00	
	Wise	0.0026648	8.0876	0.0163471	81.8480	0.0007896	1.0079	0.0001668	0.2028	91.15	0.05	
	El Paso	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Bexar	0.0173770	52.7390	0.0001719	5.8678	0.0000566	0.0723	0.1387790	168.7222	227.40	0.11	
	Comal	0.0003148	0.9554	0.0000212	0.1063	0.0000010	0.0013	0.0025142	3.0666	4.12	0.00	
	Guadalupe	0.0025314	7.6829	0.0001707	0.8548	0.0000082	0.0105	0.0020169	24.5789	33.13	0.02	
	Wilson	0.0001491	0.4524	0.0000101	0.0503	0.0000005	0.0006	0.0011905	1.4474	1.95	0.00	
	Bastrop	0.0023093	7.0088	0.0001557	0.7798	0.0000075	0.0096	0.0184432	22.4225	30.22	0.02	
Austin Area	Caldwell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Hays	0.0004586	1.3919	0.0000309	0.1549	0.0000015	0.0019	0.0036626	4.4528	6.00	0.00	
	Travis	0.0014963	10.6112	0.0002358	1.1806	0.0000114	0.0145	0.0279226	33.9473	45.75	0.02	
	Williamson	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Gregg	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Harrison	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Rusk	0.0241170	73.1948	0.1479453	740.7462	0.0071460	9.1216	0.0150594	1.8351	824.90	0.41	
	Smith	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Upshur	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Nueces	0.0037957	11.5199	0.0002560	1.2817	0.0000124	0.0158	0.0303137	36.8542	49.67	0.02	
Corpus Christi Area	San Patricio	0.0057420	17.4268	0.0003873	1.9389	0.0000187	0.0239	0.0458575	55.7517	75.14	0.04	
	Victoria	0.0013919	4.2243	0.0000939	0.4700	0.0000045	0.0058	0.0111160	13.5144	18.21	0.01	
Victoria Area	Anderson	0.0000896	0.2721	0.0005499	2.7535	0.0000266	0.0339	0.0000056	0.0068	3.07	0.00	
	Andrews	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Angelina	0.0020918	6.3485	0.0128320	64.2485	0.0006198	0.7912	0.0001309	0.1592	71.55	0.04	
	Atascosa	0.0053556	16.2541	0.0003612	1.8084	0.0000174	0.0223	0.0427716	52.0000	70.08	0.04	
	Bell	0.0003279	0.9951	0.0020113	10.0704	0.0000971	0.1240	0.0000205	0.0249	11.21	0.01	
	Bosque	0.0005396	1.6376	0.0033099	16.5725	0.0001599	0.2041	0.0000338	0.0411	18.46	0.01	
	Brazos	0.0006180	1.8755	0.0037909	18.9807	0.0001831	0.2337	0.0000387	0.0470	21.14	0.01	
	Calhoun	0.0074943	22.7451	0.0005054	2.5306	0.0000244	0.0312	0.0598521	72.7658	98.07	0.05	
	Cameron	0.0003272	0.9929	0.0000221	0.1105	0.0000011	0.0014	0.0026129	3.1766	4.28	0.00	
	Cherokee	0.0003928	1.1921	0.0002406	12.0646	0.0001164	0.1486	0.0000246	0.0299	13.44	0.01	
	Coke	0.0000132	0.0399	0.0000807	0.4043	0.0137102	17.5005	0.0000008	0.0010	17.95	0.01	
	Coleman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Colorado	0.0018297	5.5530	0.0001234	0.6178	0.0000060	0.0076	0.0146124	17.7652	23.94	0.01	
	Crockett	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Ector	0.0000665	0.2019	0.0004080	2.0428	0.062797	88.4329	0.0000042	0.0051	90.68	0.05	
	Fannin	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Fayette	0.0142622	43.2857	0.0009619	4.8160	0.0000465	0.0593	0.1139033	138.4792	186.64	0.09	
	Freestone	0.0119736	36.3396	0.0734517	367.7646	0.0035478	4.5287	0.0007484	9.9111	409.54	0.20	
	Frio	0.0075616	22.9483	0.0005100	2.5534	0.0000246	0.0314	0.0603896	73.4194	98.95	0.05	
	Goliad	0.0055754	16.9211	0.0003760	1.8827	0.0000182	0.0232	0.0445268	54.1340	72.96	0.04	
	Grayson	0.0003196	0.9700	0.0019605	9.8161	0.0000947	0.1209	0.0000200	0.0243	10.93	0.01	
	Grimes	0.0044394	13.4736	0.0272337	136.3560	0.0013154	1.6791	0.0002778	0.3378	151.85	0.08	
	Hardeman	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Haskell	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
	Hidalgo	0.0015064	4.5718	0.0001016	0.5087	0.0000049	0.0063	0.0120304	14.6262	19.71	0.01	
	Hill	0.0004153	1.2805	0.0025477	12.7561	0.0001231	0.1571	0.0000260	0.0316	14.21	0.01	
	Howard	0.0000147	0.0447	0.0000904	0.4528	0.0153564	19.8019	0.0000009	0.0011	20.10	0.01	
	Other ERCOT counties	Jack	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Jones	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Lamar	0.0020634	6.2625	0.0126581	63.3780	0.0006114	0.7804	0.0001291	0.1570	70.58	0.04
		Limestone	0.0203491	61.7593	0.1248314	625.0172	0.0060296	7.8965	0.0012736	1.5484	696.02	0.35
		Llano	0.0001567	0.4756	0.0000106	0.0529	0.0000005	0.0007	0.00012515	1.5215	2.05	0.00
		McLennan	0.0034688	10.5276	0.0212790	106.5418	0.0010278	1.3120	0.0002171	0.2639	118.65	0.06
		Midland	0.0065761	19.9584	0.0004435	2.2206	0.0000214	0.0273	0.0525191	63.8507	86.06	0.04
		Mitchell	0.0000167	0.0507	0.0001024	0.5127	0.0173890	22.1964	0.0000010	0.0013	22.76	0.01
		Nacogdoches	0.0001939	0.5883	0.0011892	5.9542	0.0000574	0.0733	0.0000121	0.0148	6.63	0.00
		Nolan	0.0000074	0.0224	0.0000452	0.2265	0.0076822	9.8061	0.0000005	0.0006	10.06	0.00
		Palo Pinto	0.0007026	2.1325	0.0043104	21.5816	0.0002082	0.2658	0.0000440	0.0535	24.03	0.01
		Pecos	0.0000003	0.0008	0.0000016	0.0082	0.0002780	0.3548	0.0000000	0.0000	0.36	0.00
		Potter	0.0003904	1.1850	0.0023951	11.9620	0.0067024	519.1403	0.0000244	0.0297	532.35	0.27
		Presidio	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00
		Reagan	0.0000002	0.0007	0.0000015	0.0076	0.0002570	0.3280	0.0000000	0.0000	0.34	0.00
Red River		0.0000354	0.1074	0.0002170	1.0865	0.0000105	0.0134	0.0000022	0.0027	1.21	0.00	
Robertson		0.0123366	37.4415	0.0755679	378.9180	0.036554	4.6660	0.0007721	0.9387	421.96	0.21	
Scurry		0.0000851	0.2582	0.0005218	2.6127	0.0886072	113.1077	0.0000053	0.0065	115.98	0.06	
Taylor		0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.0000000	0.0000	0.00	0.00	
Titus		0.0153000	46.4354	0.0938579	469.9363	0.0043335	5.7868	0.0009576	1.1642	523		

Table 3: Annual and OSP Electricity Savings for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (MWh)														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ESL-Single Family	0	25,031	47,000	74,109	153,562	215,164	275,535	360,010	533,473	722,595	916,125	1,114,311	1,317,411	1,525,690	1,739,422
ESL-Multifamily	0	50,784	108,018	200,414	332,835	527,292	774,578	1,225,617	1,856,682	2,472,527	3,115,886	3,788,639	4,492,777	5,230,406	6,003,760
ESL-Commercial	0	0	24,066	83,255	119,422	247,952	400,015	559,947	696,924	839,015	986,534	1,139,810	1,299,190	1,465,038	1,637,735
PUC (SB7)	0	538,841	976,984	1,437,883	1,831,318	2,267,414	2,675,295	3,079,759	3,498,867	3,844,949	4,173,727	4,486,067	4,782,789	5,064,675	5,332,467
SECO	0	71,910	154,786	347,175	508,375	705,060	1,004,828	1,005,713	1,100,775	1,275,938	1,442,344	1,600,428	1,750,609	1,893,281	2,028,819
Renewables-ERCOT	0	3,454,992	8,351,369	12,158,649	13,392,752	17,028,343	18,753,002	20,883,590	34,193,486	47,055,032	51,054,710	55,394,360	60,102,881	65,211,626	70,754,614
SEER13-Single Family	0	343,330	326,163	309,855	294,362	279,644	265,662	252,379	239,760	227,772	216,383	205,564	195,286	185,522	176,246
SEER13-Multi Family	0	29,021	27,569	26,191	24,881	23,637	22,456	21,333	20,266	19,253	18,290	17,376	16,507	15,682	14,897
Total Annual (MWh)	0	4,513,907	10,015,955	14,637,531	16,657,507	21,294,506	24,171,371	27,388,349	42,140,233	56,457,081	61,923,999	67,746,556	73,957,450	80,591,919	87,687,961

PROGRAM	OZONE SEASON PERIOD - OSP (MWh/day)														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ESL-Single Family	0	69	129	203	421	589	755	986	1,462	1,980	2,510	3,053	3,609	4,180	4,766
ESL-Multifamily	0	139	296	549	912	1,445	2,122	3,358	5,087	6,774	8,537	10,380	12,309	14,330	0
ESL-Commercial	0	0	66	228	327	679	1,096	1,534	1,909	2,299	2,703	3,123	3,559	4,014	4,487
PUC (SB7)	0	1,476	2,677	3,939	5,017	6,212	7,330	8,438	9,586	10,534	11,435	12,291	13,104	13,876	14,609
SECO	0	197	424	951	1,393	1,932	2,753	2,755	3,016	3,496	3,952	4,385	4,796	5,187	5,558
Renewables-ERCOT	0	15,037	26,234	30,736	32,528	31,695	46,338	63,604	86,957	96,446	104,644	113,538	123,189	133,660	145,021
SEER13-Single Family	0	2,445	2,323	2,207	2,097	1,992	1,892	1,798	1,708	1,622	1,541	1,464	1,391	1,321	1,255
SEER13-Multi Family	0	195	186	176	167	159	151	144	136	130	123	117	111	106	100
Total OSP (MWh)	0	19,559	32,334	38,990	42,862	44,703	62,436	82,617	109,861	123,280	135,444	148,350	162,069	176,674	175,797

Table 4: Annual and OSP NOx Emissions Reduction Values for the Different Programs (Base Year 2008)

PROGRAM	ANNUAL (in tons NOx)														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ESL-Single Family	0	3	8	15	34	50	65	86	129	206	263	320	379	440	502
ESL-Multifamily	0	4	19	43	77	127	190	305	468	810	1,028	1,256	1,494	1,744	2,006
ESL-Commercial	0	0	5	16	22	47	79	114	141	197	232	267	304	343	383
PUC (SB7)	0	135	246	362	460	567	669	770	874	1,326	1,438	1,545	1,646	1,742	1,833
SECO	0	19	43	92	133	183	264	265	294	400	458	514	567	617	665
Renewables-ERCOT	0	951	2,645	3,258	3,561	4,693	5,116	5,683	9,360	24,054	26,098	28,317	30,724	33,335	36,169
SEER13-Single Family	0	81	77	73	69	66	62	59	56	66	63	60	57	54	51
SEER13-Multi Family	0	7	6	6	6	6	5	5	5	6	5	5	5	5	4
Total Annual (Tons NOx)	0	1,199	3,048	3,864	4,363	5,738	6,451	7,287	11,328	27,065	29,585	32,283	35,175	38,279	41,612

PROGRAM	OZONE SEASON PERIOD - OSP (in tons NOx/day)														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ESL-Single Family	0.00	0.01	0.02	0.04	0.09	0.14	0.18	0.24	0.35	0.57	0.73	0.89	1.05	1.22	1.39
ESL-Multifamily	0.00	0.01	0.05	0.12	0.21	0.35	0.52	0.83	1.28	2.24	2.84	3.47	4.13	4.82	5.54
ESL-Commercial	0.00	0.00	0.01	0.04	0.06	0.13	0.22	0.31	0.39	0.54	0.64	0.74	0.84	0.94	1.05
PUC (SB7)	0.00	0.37	0.67	0.99	1.26	1.55	1.83	2.11	2.39	3.75	4.07	4.37	4.65	4.93	5.19
SECO	0.00	0.05	0.12	0.25	0.37	0.50	0.72	0.73	0.81	1.12	1.28	1.44	1.58	1.72	1.85
Renewables-ERCOT	0.00	4.15	7.53	8.42	8.91	9.03	12.87	17.55	24.11	50.25	54.53	59.16	64.19	69.65	75.57
SEER13-Single Family	0.00	0.57	0.54	0.51	0.49	0.46	0.44	0.42	0.40	0.48	0.46	0.44	0.41	0.39	0.37
SEER13-Multi Family	0.00	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03
Total OSP (Tons NOx)	0.00	5.20	8.99	10.41	11.42	12.20	16.82	22.22	29.76	59.00	64.58	70.53	76.90	83.71	91.00

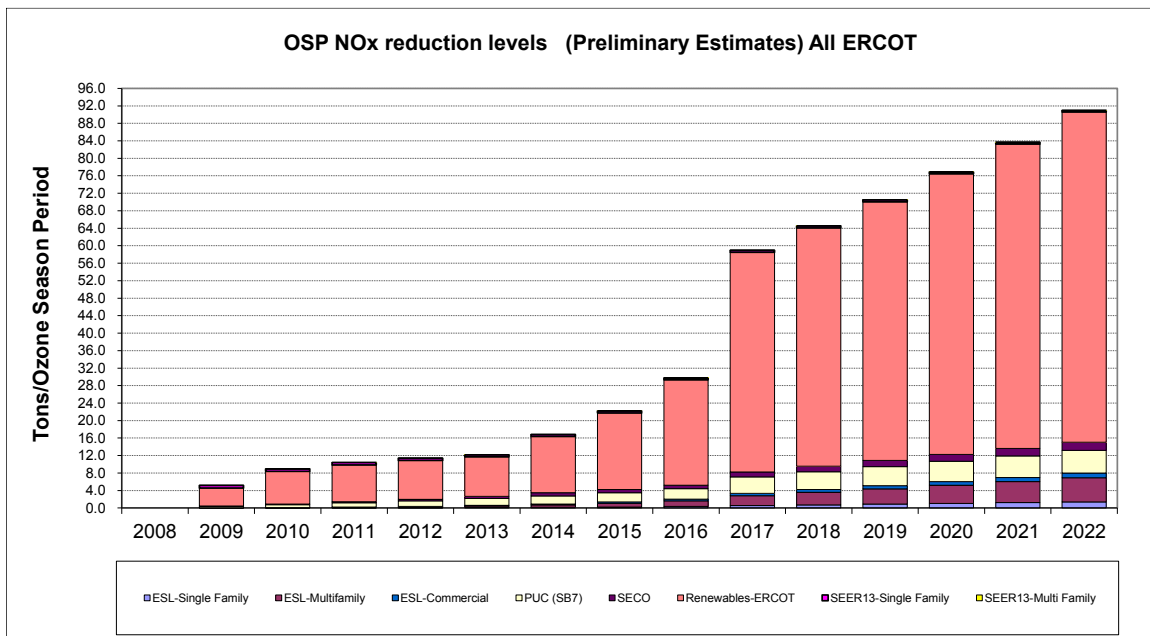


Figure 2: Integrated OSP NOx Emissions Reduction Projections through 2022 (Base Year 2008)

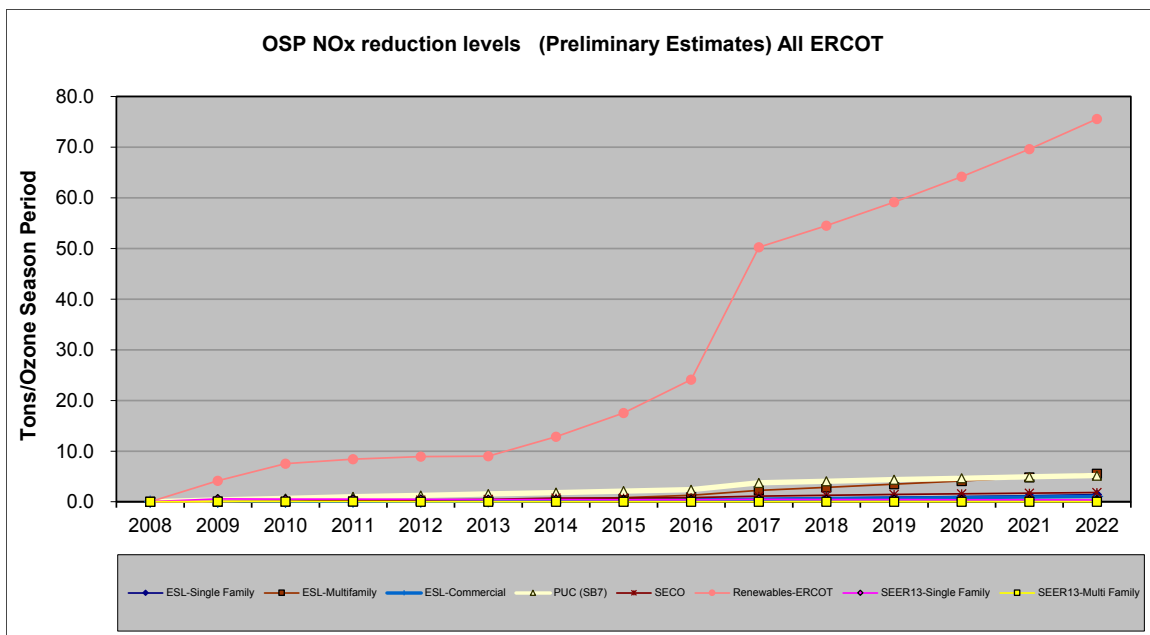


Figure 3: Integrated OSP Individual Programs NOx Emissions Reduction Projections through 2022 (Base Year 2008)

References

CBECS 1999. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report.

CBECS 2003. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report.

CBECS 2012. USDOE Commercial Building Energy Characteristics Survey. U.S.D.O.E. Energy Information Agency Report. <https://www.eia.gov/consumption/commercial/data/2012/#b34-b37>

Dodge. 2011. MarkeTrack: McGraw-Hill Construction Analytics. McGraw-Hill Construction Information Group, 148 Princeton-Hightstown Rd., Hightstown, N.J.
<http://dodge.construction.com>.

Dodge. 2017. Dodge Data & Analytics construction starts information, Texas at county level by select project types 2012-2016A. New York, NY: Dodge Data& Analytics
<https://www.construction.com/>

ICC. 2006 International Energy Conservation Code. Falls Church, VA: International Code Council, Inc.

ICC. 2009 International Energy Conservation Code. Falls Church, VA: International Code Council, Inc.

ICC. 2015 International Energy Conservation Code. Falls Church, VA: International Code Council, Inc.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, and Turner, D., 2002, “Texas’s senate Bill 5 Legislation for Reducing Pollution in Non-attainment and Affected Areas,” Annual Report to the Texas Natural Resource Conservation Commission, July, Energy Systems Laboratory Report ESL-TR-02/07-01.

Haberl, J., Culp, C., Yazdani, B., Fitzpatrick, T., Bryant, J., and Turner, D., 2003, “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP),” Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2002 to August 2003, Energy Systems Laboratory Report ESL-TR-03/12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, B., Baltazar-Cervantes, J.C., Bryant, J., Degelman, L., and Turner, D. 2004. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP),” Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2003 to August 2004, Energy Systems Laboratory Report ESL-TR-04/12-04.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, B., Baltazar-Cervantes, J.C., Bryant, J., Degelman, L., and Turner, D. 2006. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP),” Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, September 2004 to December 2005, Energy Systems Laboratory, Report ESL-TR-06-06-08.

Haberl, J., Culp, C., Yazdani, B., Gilman, D., Fitzpatrick, T., Muns, S., Verdict, M., Ahmed, M., Liu, Z., Baltazar-Cervantes, J.-C., Mukhopadhyay, J., Degelman, L., and Turner, D. 2007. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II – Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2006 to June 2007, Energy Systems Laboratory, Report ESL-TR-07-12-02.

Haberl, J. S., Liu, Z., Baltazar-Cervantes, J. C., Subbarao, K., Gilman, D., Culp, C., Yazdani, B., Turner, W. D., and Chandrasekaran, V. 2008. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2007 – December 2007, Energy Systems Laboratory, Report ESL-TR-08-12-02.

Haberl, J. S., Liu, Z., Baltazar-Cervantes, J. C., Subbarao, K., Gilman, D., Culp, C., Yazdani, B., Turner, W. D., and Chandrasekaran, V. 2009. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2008 – December 2008, Energy Systems Laboratory, Report ESL-TR-09-12-02.

Haberl, J. S., Culp, C., Yazdani, B., Lewis, C., Liu, Z., Baltazar-Cervantes, J. C., Mukhopadhyay, J., Gilman, D., Degelman, L., McKelvey, K., and Claridge, D. 2010. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2009 – December 2009, Energy Systems Laboratory, Report ESL-TR-10-12-02.

Haberl, J. S., Yazdani, B., Lewis, C., Liu, Z., Baltazar-Cervantes, J., Gilman, D., Degelman, L., McKelvey, K., Zilbertshtein, G., and Claridge, D. 2011. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2010 – December 2010, Energy Systems Laboratory, Report ESL-TR-11-12-03.

Haberl, J. S., Yazdani, B., Baltazar-Cervantes, J. C., Lewis, C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbertshtein, G., Claridge, D. 2012. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2011 – December 2011, Energy Systems Laboratory, Report ESL-TR-12-12-05.

Haberl, J. S., Yazdani, B., Baltazar-Cervantes, J. C., Parker, P., Ellis, S., Mukhopadhyay, J., Kim, H., Gilman, D., Degelman, L., Zilbertshtein, G., and Claridge, D. 2013. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume II—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2012 – December 2012, Energy Systems Laboratory, Report ESL-TR-13-10-04.

Haberl, J. S., Yazdani, B., Baltazar-Cervantes, J. C., Do, S. L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbertshtein, G., and Claridge, D. 2014. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume I—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2013 – December 2013, Energy Systems Laboratory, Report ESL-TR-14-11-01.

Haberl, J. S., Yazdani, B., Baltazar, J. C., Do, S. L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbertshtein, G., and Claridge, D. 2015. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume I—Technical Report, Annual

Report to the Texas Commission on Environmental Quality, January 2014 – December 2014, Energy Systems Laboratory, Report ESL-TR-15-11-01.

Haberl, J. S., Yazdani, B., Baltazar, J. C., Do, S. L., Ellis, S., Mukhopadhyay, J., Parker, P., Degelman, L., Zilbertshtein, G., and Claridge, D. 2016. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume I—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2015 – December 2015, Energy Systems Laboratory, Report ESL-TR-16-11-01.

Haberl, J. S., Yazdani, B., Baltazar, J. C., Ellis, S., Parker, P., Zilbertshtein, G., and Claridge, D. 2017. “Energy Efficiency/Renewable Energy Impact in the Texas Emissions Reduction Plan (TERP)”, Volume I—Technical Report, Annual Report to the Texas Commission on Environmental Quality, January 2016 – December 2016, Energy Systems Laboratory, Report ESL-TR-17-12-01.

Home Innovation Research Labs, 2013, 2014, 2015, 2016. Builder Practices Survey Reports, Upper Marlboro, Maryland.

NAHB 2008. Builder Practices Survey Reports, National Association of Home Builders, Research Center, Upper Marlboro, Maryland (September).

Kats, G. H., Rosenfeld, A. H., McGaraghan, S. A. 1996. “Energy Efficiency as a Commodity: The Emergence of an Efficiency Secondary Market for Savings in Commercial Buildings,” ACEEE Summer Study on Energy Efficiency in Buildings.

PUC 2018. Public Utility Commission of Texas, available at:
http://interchange.puc.texas.gov/Documents/26310_19_982706.PDF

USDOE. 2011. Building Energy Standard Program: Final Determination Regarding Energy Efficiency Improvements in the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ANSI/ASHRAE/IESNA Standard 90.1-2010. Federal Register 76(202):64904-64923.

USDOE. 2014. Building Energy Standard Program: Final Determination Regarding Energy Efficiency Improvements in ANSI/ASHRAE/IES Standard 90.1-2013: Energy Standard for Buildings, Except Low-Rise Residential Buildings. Federal Register 79(187):57900-57915.